ISAB APR REPORT NO. 2

Consistency of the Council's Artificial Production Policies and Implementation Strategies with Multi-Species Framework Principles and Scientific Review Team Guidelines

Independent Scientific Advisory Board

Northwest Power Planning Council
National Marine Fisheries Service
851 SW 6th Avenue, Suite 1100
Portland, OR 97204

Peter A. Bisson
Charles C. Coutant
Daniel Goodman
Robert Gramling
James Lichatowich
Eric Loudenslager
William Liss
Lyman McDonald
David Philipp
Brian Riddell

July 14, 2000
ISAB 2000-3

Consistency of the Council's Artificial Production Policies and Implementation Strategies with Multi-Species Framework Principles and Scientific Review Team Guidelines

Contents

ISAB APR REPORT NO. 2

CONSISTENCY OF THE COUNCIL'S ARTIFICIAL PRODUCTION POLICIES AND IMPLEMENTATION STRATEGIES WITH MULTI-SPECIES FRAMEWORK PRINCIPLES AND SCIENTIFIC REVIEW TEAM GUIDELINES

Background

In July 1997, Congress directed the Northwest Power Planning Council (Council) to review federally funded fish hatchery programs in the Columbia River basin, with the assistance of the Independent Scientific Advisory Board (ISAB) and the cooperation of the National Marine Fisheries Service (NMFS), the States, and the tribes. The purpose of the review, submitted to Congress in November 1999, was to provide a coordinated set of policies for hatchery operations within the Columbia River basin and recommendations for implementing the policy.

Artificial propagation of salmonid fishes has been one of the predominant features of salmon management in the Columbia basin for the past 120 years. Initially used to try to avoid implementing harvest regulations, artificial propagation has been used for the last 60 years to attempt to mitigate for habitat lost to hydroelectric system development and to augment harvest. As recently as 1991 approximately 40% of the expenditures invested in salmon restoration in the Columbia basin were used for artificial propagation (GAO 1992, cited in Return to the River, ISG 1996). By the late 1980's, adult fish produced in hatcheries comprised about 50% of the fall chinook, 70 to 80%of the spring/summer chinook, 70% of the steelhead, and 95% of the coho salmon in the Columbia basin (NMFS 1999). Releases of hatchery produced salmon and steelhead exceeded 200 million smolts in some years, with recent releases of approximately 140 million juveniles.

In the basin, juvenile salmonids are produced in over a hundred hatcheries operated by federal, state, tribal, or private organizations. Funding for hatchery operations comes from federal sources (Lower Columbia River Fishery Development Program, Grand Coulee Fish Maintenance Project, Mid-Columbia mitigation, Lower Snake River Compensation Plan, John Day Dam mitigation, Dworshak Dam mitigation, and the Northwest Power Act/Council's Fish and Wildlife Program), FERC-licensed hydropower projects (Idaho Power Company, PacificCorp, Portland General Electric Company, Washington Water Power, Douglas County PUD, Chelan County PUD, Grant County PUD, City of Portland, Cowlitz County PUD, and Tacoma Public Utilities), as well as state fish and wildlife agencies.

Although it is arguably the predominant fishery management activity in the basin, the value of artificial propagation remains controversial (ISAB 1999). While acknowledging this year's prodigious hatchery runs, over the last decade even with increasing smolt production from hatcheries, harvest and return of adult fish to spawning grounds has continued to decline. Questions have arisen as to the efficacy of artificial propagation and the management paradigm that lost habitat could mitigated by releasing fish reared in hatcheries. There is general consensus that existing data sets involving artificially propagated fish are inadequate to evaluate and monitor individual hatcheries or the artificial propagation program within the basin as a whole. Over the last decade, twelve stocks of salmon and steelhead within the Columbia basin have been listed as threatened or endangered under the federal endangered species act (ESA). Ecological, genetic, and disease interactions between artificially propagated and increasingly rare wild fish are implicated as potential causes for endangerment of those wild stocks. Harvest designed to target hatchery production is an additional source of risk to wild stocks. Three reviews by national panels: the National Research Council's Upstream: Salmon and Society in the Pacific Northwest (NRC 1996), the US Fish and Wildlife Service's National Fish Hatchery Review (NFHRP 1994), and the Council's Return to the River (ISG 1996) concur that the artificial propagation program is not fulfilling its mitigation goals and at the same time is adding risk of extinction to wild stocks. These reviews urge that artificial propagation be integrated with natural production.

Beyond questions of programmatic efficacy and expense, there has been no coordinated set of policies within the basin among the federal, state, and tribal agencies undertaking artificial propagation. This deficiency in coordination was recognized by the Council in its 1994 Fish and Wildlife Program. Section 7, Coordinated Salmon Production and Habitat, addressed the need for coordination:

> *In Sections 7.0 through 7.5, the Council calls for immediate efforts to gather data on wild and naturally spawning stocks, review impacts of the existing hatchery system and coordinate supplementation activities. ... In the Council's view, this work will greatly assist the region's decision-making processes. In the absence of this work, the Council believes that implementation of habitat and production measures will continue to suffer from inadequate information, disjointed policies, uncertainty and delay. The region should begin this work promptly, to overcome these obstacles and allow recovery efforts to proceed expeditiously*.

The U. S. Fish and Wildlife Service, the National Marine Fisheries Service and the Bonneville Power Administration jointly developed a draft programmatic environmental impact statement (EIS) on artificial production within the Columbia basin, which the Council anticipated would fulfill the need for a coordinated artificial production policy. Released in late 1996, this draft programmatic EIS received significant criticism, and the congressional directive to the Council to review hatchery operations and develop basin policy soon followed (NWPPC 1999, 99-2)

The Council appointed a Production Review Committee (PRC) to coordinate the Artificial Production Review (APR) and to assist the Council in developing artificial production policies. The Council also established a seven member Scientific Review Team (SRT) to provide independent assessment of Columbia River basin artificial production programs.

The Production Review Committee was composed of approximately 25 individuals with expertise and interest in fish production, who met once a month beginning in January 1998. Input and comment was received from hatchery managers, tribes, environmental groups, and recreational fishers. The Council also conducted two public workshops and numerous public meetings to discuss artificial production, and explain progress on the review.

The Artificial Production Review (NWPPC 1999, 99-15) is a bundled series of reports, attachments and appendices. It assesses hatchery operation goals and principles, produces a formal recommendation for a coordinated set of policies for future hatchery operations, and recommends steps to implement those policies. Included in the APR was a set of draft performance standards and indicators designed to serve as the basis for evaluating individual hatcheries and artificial production in general. These evaluations would then serve to provide needed information for making decisions, e.g., how many hatcheries are needed or appropriate in the basin, how many fish should be produced using artificial production, and how hatcheries should be operated to provide the best fish for the ecosystem.

In a letter dated November 15, 1999, the Council requested the ISAB review those performance standards and indicators focusing on three questions:

1. Are the draft performance standards and associated indicators the appropriate tools to periodically evaluate the effects of individual artificial production programs for the purpose of determining whether the principles, policies, and purposes in the Artificial Production Report (APR) are being fulfilled?

2. Are the draft performance standards and associated indicators the appropriate tools to adequately evaluate the effects of the artificial production activities in the basin?

3. If a performance standard, indicator or other means of measurement is not the most appropriate tool for this purpose, what other standard or indicator would you recommend?

The ISAB responded to that letter of request by proposing to prepare three reports dealing with the following topics:

1. Appropriateness of the Performance Standards and Indicators.

2. Consistency of Artificial Production Policies and Implementation Strategies with the Multi-Species Framework Scientific Principles and the Scientific Review Team Guidelines.

3. Development of an Appropriate Data System.

This is the second of these reports, addressing the consistency of artificial production policies and implementation strategies with Framework principles and Scientific Review Team guidelines. In developing this report, members of the ISAB reviewed background materials from the APR website, including the Council's scoping document, meeting summaries of the Production Review Committee (PRC), the facilitator's report, and drafts of the Artificial Production Review. We include in this report: (1) our understanding of how the scientific principles in the Multi-Species Framework relates to artificial production; and (2) our comments on implementing the ten artificial production policies presented in the APR. Our first report on the appropriateness of the draft performance standards and indicators (ISAB 2000) concluded that a great deal of work was still needed to develop both an acceptable set of performance standards and indicators and an acceptable procedure for their use in hatchery evaluation. Since the standards and indicators will be revised, the ISAB will not compare the consistency between policies, implementation guidelines and the original standards. Instead we make recommendations that should help develop a new set of standards.

Purpose of Report

In the artificial production review the Council reaffirmed its commitment to making artificial production decisions consistent with current understanding of scientific principles underlying ecosystem dynamics. Consequently, there should be clear connections between the implementation steps, the performance standards and indicators, artificial production policies, and the framework principles.

Council organized a 25 person Production Review Committee of hatchery/fishery managers, tribes, environmental groups, and fishers to coordinate the review and assist in developing the policies. This collegial approach is understandably desirable. Agencies and tribes within the basin are more likely to embrace the policies if they share in their development. This process, however, tends to modify proposed policies to accommodate specific extenuating conditions faced by production managers. Under these circumstances, policies, and the objectives they support can become ambiguous or even conflict with one another.

Using artificially propagated fish for harvest or recovery is controversial among basin constituencies. On the one hand, the act of rearing and releasing fish provides an opportunity to do something for recovery. On the other hand, continued declines in salmon abundance suggest that mitigation objectives cannot be reached using artificial propagation, even though most of the basin's harvested fish originate from hatcheries. The review points out that artificial production policy has been in transition within the basin for at least a decade, and that more than new policy, clear leadership is needed in using the evolving policy to determine how artificial production could be used within subbasins to reach Fish and Wildlife Program recovery objectives.

Given the polarized opinions concerning the use of artificially propagated fish and the difficulty the basin faces in establishing consensus on objectives, policies, and practices for using artificial production, the ISAB believed it prudent to review the policies, assist in identifying any conflicts, and to provide suggestions for implementing these constructive efforts.

Synopsis of recommendations

Establishing the policies presented in the artificial production review was an important and encouraging step in establishing a process to evaluate the merits of artificial production and to decide how and where to use it within the Columbia River basin. The proposed implementation process as outlined in the APR, however is inadequate. The following is a synopsis of the ISAB's recommendations.

1. A comprehensive basin-wide tagging program for artificially propagated fish, sufficient to evaluate their survival through the migration corridor, contribution to fisheries, ecological and genetic effects on naturally reproducing populations, and fish husbandry practices is required.

2. For the basin to coordinate production across hydrographic and political boundaries, clear program objectives, in the form of desired adult returns (catch plus escapement), are needed for the basin as a whole, as well as provinces, and subbasins. Program objectives for the basin, provinces, and subbasins must form the basis for the evaluation of the efficacy of current artificial production programs and to plan for future production activities. Production goals established in subbasin planning during the mid-1980's need to be revised to be consistent with the framework process.

3. A prerequisite to establishing realistic program objectives for artificial production is using the data from the tagging program to determine reasonable numbers of smolt releases from hatcheries, by province and subbasin.

4. To implement APR policy 4, subbasin planing needs to include an inventory of life history diversity within and among salmonid species, artificial propagation breeding plans that use broodstock spanning the range of life histories, and monitoring and evaluation of the impacts of artificial production on life history diversity.

5. “Hatchery reform” potentially can increase survival of artificially propagated smolts released into the Columbia River basin ecosystem. Whether increased smolt to adult survival will increase total abundance is unknown. Available data suggest lower smolt to adult survival of hatchery fish compared to wild fish. Improving hatchery practices might reduce that difference. Both wild stocks and hatchery fish are believed to have reduced return rates compared with the recent past, perhaps indicating that environmental conditions outside of the hatchery are limiting total abundance. If this is the case, increased production from hatcheries may displace wild production. An expanded hatchery program could actually yield fewer fish because of density dependent effects.

6. Although hatchery reform was a prominent feature in the report, no examples of practices that needed reforming were given, and no decision path to evaluate fish culture practices was articulated. Policies addressing fish culture practices tended to have sufficient qualifiers in the accompanying narrative to permit the full suite of current activities. We suspect that a thorough analysis would indicate various practices that could profitably be abandoned. Reform can only be accomplished if the specific practices that need reform are identified.

7. The lack of specificity as to the practices that need reform is at least partially the result of inadequate monitoring. Correcting this problem should be a priority.

8. Deviating from APR policy 5, use of naturally selected populations as the model for artificially propagated populations, should explicitly require documentation and careful evaluation. Description of non-normative practices (ISG 1999), their justification, and evaluation should receive "section" level presentation in the NMFS Hatchery and Genetic Management Plans. This would make

transparent all non-normative practices within the basin facilitating oversight by stakeholders, managers, and scientists.

9. When implementing APR policy 6, identification of the purpose of artificial production, an explicit description of the biological premises and limiting factors, including a summary of the evidence in support of those assumptions, should be required to guide development of a project.

10. For implementation to have a reasonable chance of success, it will be necessary to provide additional detailed guidance to regional managers on designing adaptive management experiments (APR policy 2), integrating artificial production into subbasin planning (APR policy 7), conducting risk analysis (APR policy 8), and developing harvest plans (APR policy 9).

11. To meet the intent of APR policy 9, production for harvest is a legitimate management objective of artificial production, the region should establish escapement targets for naturally spawning populations in major subbasins such as the Salmon, John Day, Deschutes, Yakima, Umatilla, and Imnaha rivers, and develop management mechanisms that ensure the targets are met. Because of the chronic inability to meet escapement targets, the Council should also adopt the use of minimum sustainable escapement (MSE) as recommended by the National Research Council (NRC 1996). Unlike the escapement targets, the MSE is not a goal. It is a minimum and actual escapements should always remain above the MSE in order to prevent numbers from being reduced to such low levels that recovery becomes impossible, as is apparently the case for some whale populations (Gerber 2000). It should be recognized that MSE's are thresholds below which there is significant risk to populations and their ecosystems. As such MSE’s are often different from escapement targets, which may include provisions for harvest and other human uses. Subbasin escapement targets need to include provisions for variability in abundance expected as a result of naturally occurring fluctuations in climate or ocean productivity regimes. A monitoring program should be designed to determine compliance with the escapement targets.

Relationship of the Scientific Principles in the Multi-Species Framework to Artificial Production

Reviews of Columbia River basin activities conclude that fish and wildlife restoration efforts designed using fundamental ecological principles, with the river treated as a system of interacting biological and physical components, have the greatest probability of being successful (ISG 1996, NRC 1996). From these reviews, the Multi-Species Framework Process has extracted an explicit foundation composed of eight scientific principles:

1. The abundance and productivity of fish and wildlife reflect the conditions they experience in their ecosystem over the course of their life cycle.
2. Natural ecosystems are dynamic, evolutionary, and resilient.
3. Ecosystems are structured hierarchically.
4. Ecosystems are defined relative to specific communities of plant and animal species.

5. Biological diversity accommodates environmental variation.
6. Ecosystem conditions develop primarily through natural processes.
7. Ecological management is adaptive and experimental.
8. Human actions can be key factors structuring ecosystems.

The Council policies presented in the APR are intended to be consistent with these principles. Five of the principles are particularly relevant to decision making with regard to artificial propagation:

1. The abundance and productivity of fish and wildlife reflect the conditions they experience in their ecosystem over the course of their life cycle .

Artificial propagation has been used to compensate for lost spawning areas or degraded incubation and stream rearing habitat for early life stages. The release of artificially propagated fish from the hatchery is designed to circumvent these degraded habitats. If habitat constraints limit juvenile carrying capacity throughout the river or estuary (e.g., thermal constraints, dam passage mortality, predation, and nutritional deprivation in the mainstem migration corridor, the estuary, or the ocean), releasing artificially propagated fishes probably will not increase production. Because fish released from hatcheries require the same high quality habitats and connectivity among habitats as naturally produced fish, those limiting factors decreasing the survival of naturally produced fish will most likely also decrease the survival of artificially propagated fish. Artificially produced juveniles cannot circumvent carrying capacity limits in lower reaches of major tributaries, the estuary, or the ocean. In fact, by increasing the numbers of salmonids in the system through artificial propagation, the limiting effects of these factors are likely to be exacerbated. As a result, because spatial and nutritional requirements of salmonids determine the upper limits of their population biomass, the introduction of artificially propagated fish should not be attempted unless evidence is presented that there is excess space and resources (through all of their life history) to support them.

2. Natural ecosystems are dynamic, evolutionary, and resilient.

Natural ecosystems vary in both space and time, creating a complex and dynamic set of environments within which salmon must complete their life cycle. Variations in the freshwater environment such as inter-annual changes in water flows and water temperatures affect salmon survival. It is also well documented that changing ocean conditions affect salmon survival too, and that concept has begun to be integrated into harvest management programs. Artificial production practices should accommodate both spatial and temporal variation in the salmon's ecosystem. For example, a prudent strategy during periods of poor ocean or freshwater conditions may be to reduce releases of artificially produced fish to prevent excessive competition between artificially produced and naturally spawned salmon. In short, artificial production practices should be dynamic and adaptive, allowing them to remain concordant with changes in the salmon's ecosystem.

5. Biological diversity accommodates environmental variation.

Genetic diversity coupled with a complex and dynamic habitat have given rise to a remarkable diversity of life histories that has allowed salmon to adapt to both spatial and temporal changes in their environment. Maintaining the adaptive capacity of both artificially produced and naturally spawning salmon is of paramount importance for long-term survival of these diverse stocks. Artificial production should attempt not only to maintain genetic and life history diversity of propagated stocks, but also to minimize genetic introgression with naturally spawning fish, which could erode their adaptive capacity or compromise their genetic integrity. The resilience of ecosystems depends upon the variation inherent in the component communities that define them, including the genetic variation within and among populations of each of the different organisms present. Artificial propagation needs to take all possible actions to guard against the loss of that variation, not only within populations (e.g., by using adequate numbers of adult spawners, sampling of adults across the full range of life histories, equalizing family size, etc.) but also among them (e.g., by avoiding direct stock transfers, minimizing straying, etc.). Any evaluation of the impact (positive or negative) of artificial propagation needs to assess the long-term effects on genetic structure of the remaining wild populations.

7. Ecological management is adaptive and experimental.

Many of the scientific principles in the Multi-Species Framework and guidelines in the SRT review are conceptual, drawn from accepted ecological theory. Only for a limited set of guidelines do we have supportive evidence from actual data sets. For example, within the Deschutes River, the smolt to adult ratio is higher in spring chinook reared relatively naturally in the Pelton fish ladder than in spring chinook reared more traditionally at the Warm Springs National Fish Hatchery (Beckman, *et al.* 1999). This observation supports rearing fish at reduced densities and manipulating growth rates to mimic patterns observed in wild stocks. Uncertainty of future ecosystem conditions owing to both anthropogenic alterations and natural variation limits predicting the success of artificial production as a management tool. Consequently, artificial production is experimental and continual monitoring sufficient to identify inevitable surprises is necessary.

8. Human actions can be key factors structuring ecosystems.

Fish propagation activity in the Columbia River can influence the ecosystem through the direct effects of releasing artificially produced fish and the indirect effects that result from management actions (Campton 1995). For example, direct effects of hatchery fish include genetic and ecological interactions with naturally spawning fish, while indirect managerial effects include excessive harvest in mixed stock fisheries and an expectation that hatcheries can substitute for prudent habitat management. Through both these direct and managerial effects artificial production activities could compromise achieving basin fish and wildlife program goals for naturally produced fish.

Council Policies for Artificial Propagation

The Council used the scientific principles and the guidelines contained in the SRT report to formulate ten policies governing the use of artificial propagation in the Columbia Basin:

1. The manner of use and the value of artificial production must be considered in the context of the environment in which it is used.
2. Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate benefits and address scientific uncertainties.
3. Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.
4. A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.
5. Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.
6. The entities authorizing or managing an artificial production facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.
7. Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.
8. Appropriate risk management needs to be maintained in using the tool of artificial propagation.
9. Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of artificially produced populations, harvest rates and practices must be dictated by the requirements to sustain naturally spawning populations.
10. Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

The intent of the policies, together with the recommended plan for implementation, is twofold. First it is to prompt immediate changes in hatchery operations where they are inconsistent with current conceptual hypotheses concerning fish and wildlife populations within the multi-species framework. Second, it is to provide a mechanism to monitor and evaluate artificial propagation so the following questions can be assessed on an ongoing basis:

- *Can artificial propagation be revised to spread harvest opportunities to greater areas of the basin?*

- *What artificial propagation activities adversely affect wild fish to a significant degree and thus undermine efforts to protect and rebuild wild runs?*

- *Can artificial propagation be used to assist in the preservation and rebuilding of naturally spawning populations?*

ISAB Comments on Implementing the APR's Artificial Production Policies Consistent with the Scientific Principles in the Multi-Species Framework and the SRT Guidelines

The ISAB was asked to evaluate the performance standards and indicators attachment to the APR. We determined that adequate review of any set of performance standards and indicators required a full examination of their consistency with artificial production goals, policies, implementation strategies, and the scientific principles they are intended to support. We provide our findings below and, to the extent practical, format our response to answer the three questions we were asked regarding the adequacy of the performance standards and indicators. In the Council's APR, individual policies and implementation steps are followed by a narrative explanation. We employ the same format, following each policy statement is the consensus ISAB view on the underlying science principles, implementation strategies, and possible relationship to a revised set of performance standards and indicators.

1. The manner of use and the value of artificial production must be considered in the context of the environment in which it is used.

To survive and grow following release, salmon and steelhead smolts need high quality environmental conditions. The numbers of adult fish produced through artificial production is constrained by the environment into which smolts are released. A prerequisite to establishing realistic program objectives for artificial production is evaluating the basin carrying capacity and limiting factors. Artificial production programs, especially those designed to mitigate for habitat loss above a dam, need to consider the carrying capacity of the environment below the dam when establishing release numbers.

In the Council's 1994 Fish and Wildlife Program, section 7.1A. Evaluation of Carrying Capacity, called for evaluating salmon survival in the Columbia River, its estuary, and the near-shore ocean. It was anticipated this study would yield information on the carrying capacity of the system and on the factors that limit salmon survival under current conditions. This information is imperative if managers are to reach consensus on numbers of propagated fish to be released and their locations. The 1994 Fish and Wildlife Program also called for hatchery release numbers to be consistent with basin carrying capacity: (7.1G. Adjust total number of hatchery fish released to stay within basin carrying capacity).

In 1996 workshops were convened and reports prepared on an evaluation of carrying capacity in regard to section 7.1A. One of the reports concluded, "The approach inherent in 7.1A will not increase understanding of ecology, carrying capacity or limiting factors that influence salmon under current conditions." Further, "To pursue the capacity parameter, that is, a single number or set of numbers that quantify how many salmon the basin or any part of the basin can support, is meaningless by itself and will not provide useful information." Based on this workshop and the report, management of artificial production in the context of capacity was largely dropped.

The challenge of recommending future actions remains. There are several unresolved problems: one is the difficulty of estimating carrying capacity, a second is that carrying capacity will vary in time, and a third is a well founded belief that carrying capacity (density dependence) will effect the survival of both natural and hatchery juveniles. Unfortunately that still leaves the basin with the upper bounds for appropriate release numbers unresolved. Just because an answer to the carrying capacity question is not easily amenable to investigation does not mean that density dependent effects will not influence salmon abundance and should be ignored.

Experiments could be undertaken, not to estimate basin carrying capacity, but to evaluate release numbers. Over a period of many years, acceptable release numbers may emerge. Given the changes in the river (dams/reservoirs) and degradation in the estuary, we should estimate an upper limit to the density of hatchery and wild fish in the migration corridor and estuary. Basin managers simply cannot continue to propose more and more hatchery releases during the short migration window without initiating long-term experiments to determine if there are density constraints. We acknowledge, however that it will be difficult to design the experiments from which appropriate estimates can be derived.

2. **Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate benefits and address scientific uncertainties.**

As conceived by its proponents (Holling 1978, Walters 1986), adaptive management is more sophisticated than a simple trial and error learning approach or program implementation through sets of unrelated experiments intended to improve individual hatchery facilities. It would use the artificial production program as a vehicle to test explicit uncertainties regarding policy options for the use of artificial production to achieve basin objectives.

Staff trained in experimental design and statistical analysis, together with regional coordination of project planning and implementation will be required to use this approach. Coordinating agencies should have independent scientists design a long-term management experiment in which all artificial production facilities participate to receive funding and/or NMFS permits under the ESA. The duration of this experiment is likely to be decades not years, i.e., long enough to adequately resolve the important questions surrounding the use of artificial propagation. The previously identified problem of determining basin carrying capacity and/or upper limits for hatchery smolt releases is one of the questions that might be answered in this way.

3. **Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.**

Natural ecosystems fluctuate, producing considerable variation in survival and growth of salmon. Salmon harvests have historically been highly variable. Increasing yields and stabilizing them have been motivations for using artificial production, but recent analysis argues that these attempts have not been successful (Hilborn and Eggers 2000). Consequently, artificial production practices should accommodate variation in the salmon's ecosystem. For example, a prudent strategy during periods of poor ocean or freshwater conditions may be to reduce releases of artificially produced fish to prevent excessive competition with each other and with naturally spawned salmon. The numbers of released fish might parallel the numbers of naturally produced smolts rather than attempting to make up perceived deficits. Performance standards and indicators need to be flexible in ways that recognize changing environmental conditions and natural salmon producing capacity.

4. A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.

Part of the subbasin planning process should include the creation of an inventory of the life history diversity within and among the salmonid species as they pass through different regulatory jurisdictions, including current and historical, in so far as possible. To avoid unintentional selection that might compromise the ability of the resulting offspring to survive environmental changes, egg take from wild individuals or returning hatchery adults needs to span the entire range of life histories such as run times and spawning locations. Part of the subbasin level set of performance standards and indicators should address the need to evaluate the impacts of artificial propagation on that diversity within each subbasin. The hypothesis that subbasins with higher levels of diversity, both within and among species, produce more fish should be tested. Collecting and analyzing this type of data will require new institutional organization and cooperation. The Washington Department of Fish and Wildlife has been conducting this type of research in the Yakima basin (the species interactions group) and this model should be expanded.

5. Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.

This policy addresses a variety of hatchery production and release practices: broodstock selection, broodstock collection, mating designs, incubation conditions, water sources, rearing densities and conditions, growth programs, and release strategies. Experience gained in the Columbia River basin and elsewhere in the Pacific northwest provides evidentiary support for the concept that populations drawn from the wild and reared under conditions as natural as possible tend to perform better after release than populations that experienced directed selection or were cultured for many generations.

One example is the superior performance of spring chinook reared in and volitionally released from the Pelton fish ladder compared with those reared and released from Warm Springs National and Round Butte hatcheries (Beckman *et al*. 1999). A second example is the generally poor performance in the Kalama River of Washougal summer steelhead of hatchery origin compared with native steelhead of wild origin (Chilcote *et al*. 1986). Both practitioners and managers need to be mindful that specific recommendations for hatchery protocols will undoubtedly change through time as new information becomes available. SRT guidelines 1, 2, 4, 5, 6, 7, 8,9, 10, 11, 12, and 13 apply to this policy.

There is qualifying language accompanying the policy that appears to accommodate fish culture practices that are inconsistent with the policy. As an example, not mimicking natural release size or migration times is asserted to increase survival of the fish under certain situations, although no evidence is presented or cited. Even though the assertion may be true, the practice would alter the selection regimes that the population experiences and likely would be inconsistent with efforts to conserve normative behavior in the fish.

Also mentioned is a counter-hypothesis proposing that, "at least in some situations, it is best for artificial production managers to avoid mimicking the release times, places, and conditions of natural populations to avoid harmful competition, predation, and other adverse interactions" (APR, Policy 5, page 19). We can appreciate that managers may wish to design programs that release hatchery smolts at times designed to avoid interaction with outmigrating naturally produced fish. In fact, there are programs intentionally selecting for run times and spawning times that avoid interacting with wild fish. In the case of steelhead and cutthroat trout in the lower Columbia basin, these programs generally are intended to provide fish for recreational harvest. The intent is to provide sport-angling opportunities/harvest without impacting wild fish. Within this program natural and hatchery spawners are not supposed to overlap in breeding time (and possibly breeding location), and the early timing of hatchery spawning in the wild is supposed to ensure poor survival of those offspring. Of course, a lack of complete reproductive isolation could create the worst case scenario, wild fish interbreeding with directionally selected, artificially propagated fish. Although we lack appropriate confirmation, anecdotal reports from a coastal example of this type of program revealed more overlap in return time than planned, as well as the fact that adults produced in the directed selection program in the hatchery were mating in the wild with naturally produced fish.

Accompanying text suggests that this policy applies primarily to programs attempting to improve survival of artificially produced fish, to avoid adverse impacts on natural populations, or to use artificial production to try to restore naturally spawning populations. This suggestion implies, therefore, that the large lower river programs providing fish for harvest in the ocean and lower river do not need to consider these policies. Prudence would apply this policy to all programs.

There are other programs with components that seem inconsistent with this policy. Once again, in this review we are not evaluating data, so no judgments of efficacy are being made or implied, just observations of operational protocols. For example, portions of the Lower Snake River Compensation hatchery system collect steelhead eggs from the Salmon river and then incubate, hatch, and rear smolts using 15 C isothermal water at Magic Valley and Niagara Springs hatcheries in the Hagermann Valley region of Idaho, between Boise and Twin Falls. Smolts are trucked to Salmon River tributaries/lower Snake River for release without acclimation (Hutchison 1992). These programs are clearly not consistent with normative concepts. Whether their smolt-to-adult ratio is better or worse than artificial production programs using ambient water supplies, and/or acclimation should be of interest to program managers.

In applying this policy the APR recommends that decisions to deviate from the biological characteristics of the naturally spawning population require documentation and careful evaluation. Description of non-normative practices, their justification, and evaluation should receive "section" level presentation in the NMFS Hatchery and Genetic Management Plans. This would make transparent all non-normative practices within the basin, facilitating a more appropriate level of oversight by stakeholders, managers, and scientists.

6. **The entities authorizing or managing an artificial production facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.**

Selecting a purpose for an artificial propagation project from a designed list is likely insufficient for its integration into the basin wide program. Successful programs complement the life history of the propagated species by using hatchery culture to address the portion of the life cycle limiting production (Brannon et al. 1999). Identifying a purpose for each project guides its conceptual framework and forms the basis for evaluation. An explicit description of the biological premises and limiting factors, including a summary of the evidence in support of those assumptions, should be required to guide development of a project. In addition, the purpose articulated for each hatchery should be explicitly required in basin, province and subbasin level planning efforts.

7. **Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.**

Although hatcheries are localized actions, they represent responses to much larger scale problems such as the loss of harvest opportunity or large-scale habitat loss. This concept is reflected in the program framework and the scientific principles. The impacts of hatcheries, both positive and negative, extend far beyond the location, watershed and subbasin in which they are located. However, because hatcheries represent complex localized engineering and biological problems, the focus often becomes localized. The connection to the larger scale problem for which the hatchery was a response is often lost. Decisions to utilize hatcheries at a subbasin level need to reflect these larger scale considerations.

In a like manner, evaluation of hatcheries needs to distinguish the strategic question, that is often addressed at province or basin scales from the tactical evaluation of individual facilities at local scales. Hatcheries are usually evaluated at the local level in regard to performance or compliance with underlying criteria (pounds of fish released, for example). Strategic questions regarding the efficacy of artificial production to mitigate for loss of natural ecological function, for example have rarely been addressed.

8. Appropriate risk management needs to be maintained in using the tool of artificial propagation.

Using technological tools, such as artificial production, to solve problems, such as mitigation for effects of dams, carries with it uncertainty as to the outcome. This uncertainty, or risk, is common in situations that involve the use of technology. In the fields of medicine, finance, and manufacturing, there are established management systems to forecast unintended events. With environmental problems, particularly toxicology and biotechnology, treatment of "risk" is commonplace (Cothern, 1992). In fisheries management there is conceptual interest in using risk management, but consensus on tools and methods is only beginning to emerge (Lane and Stephenson 1998, Francis and Shotton 1997). Given the lack of consensus on how to treat risk in fisheries management, policies calling for its maintenance can be confusing. The ISAB endorses developing risk management/assessment strategies for artificial production and consistent application of these strategies throughout the basin. Developing and using an accepted risk management strategy would be an appropriate performance standard.

There are very different types of uncertainty associated with artificial production within the Columbia River basin. There is uncertainty whether or not artificial production can in fact achieve program objectives: *mitigate* spawning and rearing habitat loss due to dams; *supplement* wild stocks to rebuild populations; *captively maintain broodstock* of populations near extinction. There is also the uncertainty of unintended detrimental genetic and ecological impacts from collecting wild broodstock and releasing juvenile salmonids into rivers, streams, and lakes. Different risk evaluation procedures are needed to address these uncertainties, and different risk management strategies are needed to reduce them (Currens and Busack 1995). Although not yet widely implemented, approaches for assessing detrimental genetic (Busack and Currens 1995, Currens and Busack 1995) and ecological consequences (Pearsons and Hopley 1999) of using artificially propagated fish within the Columbia basin have been proposed. To our knowledge there is no formal risk management program in place or underway to address the uncertainty associated with artificial production.

Tools developed for managing risk in toxicology and biotechnology are not likely to be appropriate for artificial production of salmon (Currens 1993). In the case of toxic substances and biotechnology, management concentrates on procedures to contain materials or control exposure. Since artificially produced salmon are released into the environment where they interact with other species, containment is clearly not the issue. With artificial production there is a need to identify when unintended detrimental outcomes from interaction with other species occur, and have in place procedures to respond to these failures. Currens and Busack (1995) stress that hazards associated with artificial production can be managed by taking steps to reduce the likelihood of unintended adverse outcomes and by quickly responding to correct mistakes. They believe efforts have tended to focus on technological solutions to reducing the likelihood of a hazard occurring. Because the history of success in using technological solutions is not very good they conclude that greater attention should be given to identifying and responding to failures. Adaptive management and monitoring to identify failures and a salmon reserve system together with normative ecosystem conditions could be components of this type of risk management strategy (Currens 1993, ISG 1996).

9. Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of artificially produced populations, harvest rates and practices must be dictated by the requirements to sustain naturally spawning populations.

Harvest and hatchery programs are tightly linked under the broad umbrella of salmon management. Direct augmentation of harvest is one of the purposes of artificial propagation listed in the APR, and hatchery programs designed for other purposes (mitigation and restoration) are usually expected to contribute to the fisheries. In watersheds like the Columbia with severe habitat degradation and long histories of over harvest, hatchery programs may provide the majority of fishing opportunity. For example, in 1994, 81% of the commercial salmon landings below Bonneville Dam were attributed to the Youngs Bay terminal fishery. This fishery primarily harvests hatchery coho and fall chinook (ODFW and WDFW 1995).

Policy 9 is related to six of the original performance standards listed in the APR. The number of performance standards related to harvest emphasizes the close relationship between harvest and artificial propagation of salmon. Policy 9 suggests that protection of naturally spawning populations is the priority in the harvest regulation of mixed stock fisheries.

Proper harvest management is critical when the hatchery fish are mixed with returning wild salmon in the fishing areas. The near extirpation of wild coho salmon in the lower Columbia River tributaries was attributed in part to over harvest in mixed stock fisheries (Flagg *et al*. 1995). Policy 9 clearly attempts to avoid a repeat of this problem. Inconsistencies between the policy and the expectations implied in the performance standards, however, leave doubts as to whether the intent of policy 9 can be met.

Language in the APR suggesting that hatcheries will provide "predictable, stable and increased harvest opportunity" appears to establish expectations that are biologically impossible to meet and may compromise the intent of policy 9 unless clear priorities are established. Harvest management has to recognize the existence of natural environmental fluctuations that influence the abundance of salmon of both hatchery and natural origin. Harvest regimes should be organized so they can effectively respond to those fluctuations. Maintaining the expectation of stable harvest can lead to over harvest of naturally reproducing populations during periods when climatic conditions result in reduced survival and abundance.

There is a need to meet legal and policy obligations to the Tribes and to enhance Tribal, local, state, and national economies by increasing harvest through the use of hatchery fish as expressed in the APR. Those expectations must recognize natural fluctuations in abundance of salmon and the need to meet the minimum escapement needs of naturally reproducing populations. It is not clear that the APR recognizes those biological constraints or gives adequate priority to the protection of naturally spawning populations. The APR should state the priorities among legal, policy, and economic considerations as well as biological requirements of wild populations.

To meet the intent of Policy 9, the region should establish escapement targets by major subbasin for naturally spawning populations such as the Salmon, John Day, Deschutes, Yakima, Umatilla and Imnaha rivers, and develop management mechanisms that ensure the targets are met. Because of the chronic inability to meet escapement targets, the Council should also adopt the use of minimum sustainable escapement (MSE) as recommended by the National Research Council (NRC 1996). Unlike the escapement targets the MSE is not a goal. It is a minimum and actual escapements should remain above the MSE. Establishment of a MSE safety net should include consideration of population viability, genetic integrity, and natural subbasin productivity. Subbasin escapement targets should reflect the fluctuations in abundance expected as a result of naturally occurring fluctuations in climate or ocean productivity regimes. A monitoring program should be designed to determine compliance with the escapement targets.

10. Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

Obligations for fish mitigation as a consequence of specific legislation, e.g.. Lower Snake Compensation Plan and Mitchell Act, legal requirements contained within the Endangered Species Act, and the outcome of litigation such as U.S. v. Oregon create challenges to implementing the monitoring and adaptive experimentation necessary to evaluate and modify hatchery practices. There may be instances where legal or legislative goals for escapement targets conflict with the requirements for controls and replication in the design of adaptive management experiments. In other circumstances, if the loss of fishing opportunities or reduction in employment in hatcheries is concentrated within only a few political jurisdictions, these regions are unlikely to cooperate in management experimentation. To fully address the legal mandates and obligations while conducting the monitoring, experimentation and evaluation will require developing mechanisms to accommodate variable hatchery production in facilities and cooperation across political and bioregional boundaries.

Appendix 1: SRT Suggested Guidelines on Hatchery Practices, Ecological Integration and Genetics

Guideline 1. Technology should be developed and used to more closely resemble natural incubation and rearing conditions in salmonid hatchery propagation.

In developing hatchery technology, hatchery programs should work toward the goal of providing environments that resemble natural conditions during artificial propagation.

These may include:
- Incubation in substrate and darkness;
- Incubation at lower densities;
- Rearing at lower densities;
- Rearing with shade cover available;
- Exposure to in-pond, natural-like habitat;
- Rearing in variable, higher velocity habitat;
- Non-demand food distribution during rearing;
- Exposure to predator training;
- Minimize fish-human interaction;
- Acclimation ponds at release sites;
- Volitional emigration from release sites.

Guideline 2. Hatchery facilities need to be designed and engineered to represent natural incubation and rearing habitat, simulating incubation and rearing experiences complementary with expectations of wild fish in natural habitat.

Guideline 3. New hatchery technology for improving fish quality and performance needs to have a plan for implementation and review at all hatchery sites, where appropriate, to assure its application.

Guideline 4. To mimic natural populations, anadromous hatchery production strategy should target natural population parameters in size and timing among emigrating anadromous juveniles to synchronize with environmental forces shaping natural population structure.

Guideline 5. To mimic natural populations, resident hatchery production strategy should target population parameters in size and release timing of hatchery-produced resident juveniles to correspond with adequate food availability and favorable prey to maximize their post-stocking growth and survival.

Guideline 6. Supplementation hatchery policy should utilize ambient natal stream habitat temperatures to reinforce genetic compatibility with local environments and provide the linkage between stock and habitat that is responsible for population structure of stocks from which hatchery fish are generated.

Guideline 7. Salmonid hatchery incubation and rearing experiences should use the natal stream water source whenever possible to enhance home stream recognition.

Guideline 8. Hatchery release strategies need to follow standards that accommodate reasonable numerical limits determined by the carrying capacity of the receiving stream to accommodate residence needs of non-migrating members of the release population.

Guideline 9. Hatchery programs should dedicate significant effort in developing small facilitates designed for specific stream sites where supplementation and enhancement objectives are sought, using local stocks and ambient water in the facilities designed around engineered habitat to simulate the natural stream, whenever possible.

Guideline 10. Genetic and breeding protocols consistent with local stock structure need to be developed and faithfully adhered to as a mechanism to minimize potential negative hatchery effects on wild populations and to maximize the positive benefits that hatcheries can contribute to the recovery and maintenance of salmonids in the Columbia ecosystem.

Guideline 11. Hatchery propagation should use large breeding populations to minimize inbreeding effects and maintain what genetic diversity is present within the population.

Guideline 12. Hatchery supplementation programs should avoid using strays in breeding operations with returning fish.

Guideline 13. Restoration of extirpated populations should follow genetic guidelines to maximize the potential for re-establishing self-sustaining populations. Once initiated, subsequent effort must concentrate on allowing selection to work by discontinuing introductions.

Guideline 14. Germ plasm repositories should be developed to preserve genetic diversity for application in future recovery and restoration projects in the basin, and to maintain a gene bank to reinforce diversity among small-inbred natural populations.

Guideline 15. The physical and genetic status of all natural populations of anadromous and resident fishes need to be understood and routinely reviewed as the basis of management planning for artificial production.

Guideline 16. An in-hatchery fish monitoring program needs to be developed on performance of juveniles under culture, including genetic assessment to ascertain if breeding protocol is maintaining wild stock genotypic characteristics.

Guideline 17. A hatchery fish monitoring program needs to be developed on performance from release to return, including information on survival success, interception distribution, behavior, and genotypic changes experienced from selection between release and return.

Guideline 18. A study is required to determine cost of monitoring hatchery performance and sources of funding.

Guideline 19. Regular performance audits of artificial production objectives should be undertaken, and where they are not successful, research should be initiated to resolve the problem.

Guideline 20. The NPPC should appoint an independent peer review panel to develop a basinwide artificial production program plan to meet the ecological framework goals for hatchery management of anadromous and resident species.

Literature Cited

Beckman, Brian R. and 10 Coauthors. 1999. Growth, smoltification, and smolt-to-adult return of spring chinook salmon from hatcheries on the Deschutes River, Oregon. American Fisheries Society 128:1125-1150.

Brannon, Ernest L and 6 Coauthors. 1999. Review of artificial production of anadromous and resident fish in the Columbia River basin, Part I. a scientific basis for Columbia River production program, 139 p. Northwest Power Planning Council, Portland, Oregon.

Busack, C. 1990. Yakima/Klickitat production project genetic risk assessment. Yakima/Klicitat Production Project Design Report, Appendix A, BP-00245-2. Bonneville Power Administration, Portland, Oregon.

Busack, C. A. and K. P. Currens. 1995. Genetic risks and hazards in hatchery operations: fundamental concepts and issues. American Fisheries Society Symposium 15:71-80.

Campton, D. 1995. Genetic effects of hatchery fish on wild populations of Pacific salmon and steelhead: what do we really know? American Fisheries Society Symposium 15:337-353.

Chilcote, M. W., S. A. Leider, and J. J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115:726-735.

Cothern, R. C. 1992. Comparative environmental risk assessment. Lewis Publishers, Ann Arbor, Michigan.

Currens, K. P. 1993. Genetic vulnerability of the Yakima fishery project: A risk assessment. Oregon Cooperative Fishery Unit Genetic Laboratory. Report No. 93 (2). Oregon State University, Corvallis, Oregon.

Currens, K. P. and C. A. Busack. 1995. A framework for assessing genetic vulnerability. Fisheries 20 (12):24-31.

Flagg, T. A., F. W. Waknitz, D. J. Maynard, G. B. Milner and C. V. W. Mahnken. 1995. The effect of hatcheries on native coho salmon populations in the lower Columbia River. Pages 366-375 in H. L. Schramm, Jr. and R. G. Piper (eds.) *Uses and Effects of Cultured Fishes in Aquatic Ecosystems*. American Fisheries Society Symposium 15, Bethesda, MD.

Francis, R. I. C. C., and R. Shotton. 1997. "Risk" in fisheries management: a review. Can. J. Fish. Aquat. Sci. 54:1699-1715.

Gerber, L. R., D. P. DeMaster, and S. P. Roberts. 2000. Measuring success in conservation. American Scientist 88:316-324.

Hilborn, R. and D. Eggers. 2000. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 129:333-350.

Holling, C. S., editor. 1978. Adaptive environmental assessment and management. John Wiley, New York, New York.

Hutchison, B. 1992. Operations Plans for anadromous fish production facilities in the Columbia River Basin, Volume II: Idaho Department of Fish and Game Hatcheries. Bonneville Power Administration Project Number 92-043. Bonneville Power Administration, Portland, Oregon.

Independent Scientific Advisory Board. 1999. Looking for common ground: Comparison of recent reports pertaining to salmon recovery in the Columbia River basin (ISAB 99-3). Northwest Power Planning Council, Portland, Oregon.

Independent Scientific Advisory Board. 2000. ISAB review of the performance standards and indicators for artificial production in the Council's Artificial Production Review (ISAB 2000-2). Northwest Power Planning Council, Portland, Oregon. www.nwppc.org/isab2002.pdf

Independent Scientific Group. 1996. Return to the river. Northwest Power Planning Council, Portland, Oregon. www.nwppc.org/ftpfish.htm - I2

Independent Scientific Group. 1999. Return to the river: scientific issues in the restoration of salmonid fishes in the Columbia River. Fisheries 24(3):10-19.

Lane, D. E., and R. L. Stephenson. 1998. A framework for risk analysis in fisheries decision-making. ICES J. Mar. Sci. 55:1-13.

National Fish Hatchery Review Panel (NFHRP). 1994. Report of the National Fish Hatchery Review Panel. The Conservation Fund, Arlington, Virginia.

National Marine Fisheries Service. 1999. Biological opinion on artificial propagation in the Columbia River Basin. NMFS, Columbia River Fisheries Development Office, Portland, Oregon.

National Research Council (NRC). 1996. Upstream: Salmon and society in the Pacific Northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Academy of Science, Washington, D.C

Northwest Power Planning Council. 1999. Facilitator's Report on the Columbia River Basin Artificial Production Workshop. Report 99-2. NWPPC, Portland, Oregon. www.nwppc.org/99-2_rep.htm

Northwest Power Planning Council. 1999. Artificial Production Review. Report 99-15. NWPPC, Portland, Oregon. www.nwppc.org/99-15.htm

Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. 1995. Status report: Columbia River fish runs and fisheries, 1938-1994, Olympia, WA.

Pearsons, T. N., and C. W. Hopley. 1999. A practical approach for assessing ecological risks associated with fish stocking programs. Fisheries 24 (9):16-23.

Walters, C. J. 1986. Adaptive management of renewable resources. McMillan, New York, New York.

w:\em\ww\isab\1 isab final reports\isab 2000-3 apr basis.doc